Exploration of Deep Seamount Biology and Geology

The Johnston Atoll Unit of the Pacific Remote Island Marine National Monument

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Between May 25 and July 13, 2022, E/V *Nautilus* mapped and explored four regions within the Johnston Atoll Unit of the Pacific Remote Islands Marine National Monument (PRIMNM) during two back-to-back expeditions (Figure 1). While the focus of these expeditions revolved around maximizing near-bottom observations and sampling of geology and diverse biology, a combined total of 42,493 km^2 of previously uncharted seafloor was also mapped within the Monument.

A total of 13 ROV dives amassed over 210 hours of bottom time and traversed ~40 km of seafloor. Bottom time of dives ranged from 9 to 27 hours across 1 to 2.5 km of seafloor and covered 100 to 1,500 m of vertical relief.

A record number 278 samples were collected on this expedition. Biological samples accounted for the majority (60%), followed by geological samples (38%) and fossilized biological material (2%). Biological samples included 53 corals, sponges, and anemones; 39 sea cucumbers, urchins, and sea stars; 27 Niskin bottle water samples for environmental DNA; and six potential fossils including a *Megalodon* tooth, whale bones, and sponges. Geological samples included 90 rock samples of mostly iron-manganese encrusted basalt with one limestone sample, 10 collections of marble- to softball-sized iron-manganese encrusted nodules (Figure 2), and four push cores. Selective sampling of biota and rocks was a priority to better characterize the biodiversity and geologic settings of the four regions.

Several different morphologies of seamounts, guyots, and elongate ridges were explored in the four regions (e.g., Figure 3). In the southeastern region, three dives were located along ridges radiating from a seamount (H1926, H1928, H1930), and another dive was along a ridge consisting of a series of subtle cones flanking a guyot (H1927). In the western region, one dive was located along a section of a 100 km-long east-west trending ridge (H1931). Two other dives (H1932, H1933) explored ridges radiating from guyots that may be remnants of slope failures or mass-wasting events. Dives at Johnston Atoll (H1934, H1935) provided a continuous transect up the western flank of a prototypical atoll, with basalt transitioning to coral reef material up the slope. Seamount morphologies in the northern region did not have the radiating ridge patterns observed in the other regions, but were more circular in shape. Their cross sections were different, with one seamount presenting a more classic conical shape (H1936), another with more of a pancake morphology (H1938), and another with a possible caldera at the top (H1937). The final dive of the expedition (H1940) was along the northern flank of a guyot capped by a 15 km-diameter plateau. An interesting morphology seen in this northern region was an abundance of numerous, <500 m-high cones flanking the seamounts and guyots.

Preliminary observations indicate that the majority of rocks recovered represent a mixture of alkalic and highly silica undersaturated (e.g., trachytic) lithologies, consistent with previous reports from the region. The presence

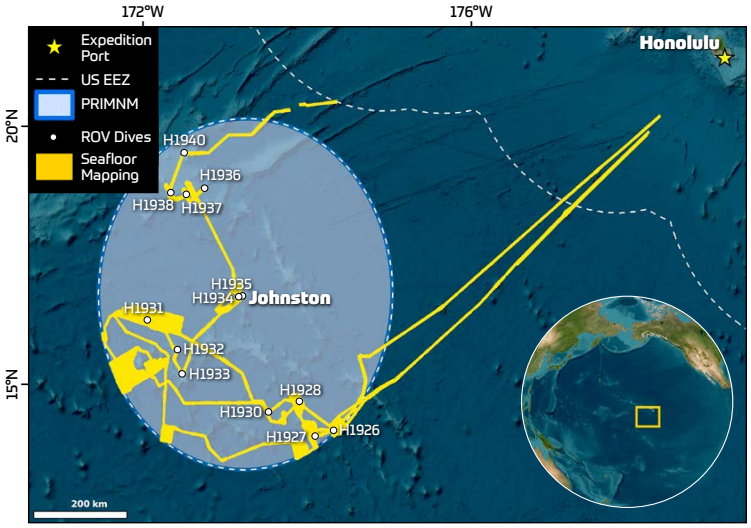


FIGURE 1. Track lines show areas that were mapped and explored via ROV during expeditions NA140 and NA141 aboard *E/V Nautilus*.

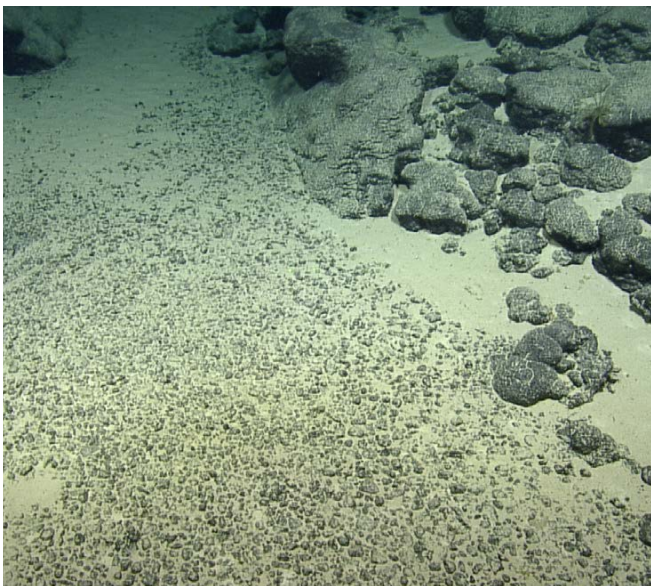
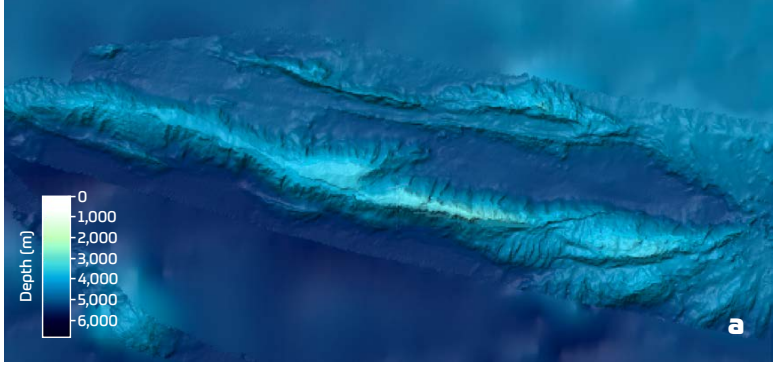


FIGURE 2. A drift of marble- to softball-sized iron-manganese encrusted nodules observed and collected during the NA141 expedition.



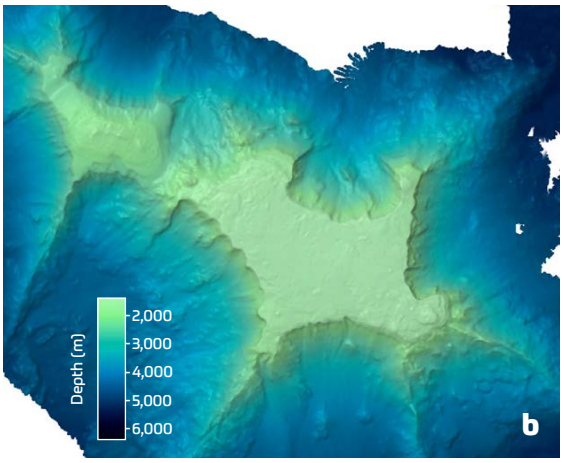


FIGURE 3. (a) Newly mapped elongate ridges of unknown origin. (b) Wetmore Seamount, an example of a guyot with radiating ridge morphology.

of basalt atop some guyots (e.g., Guyot S4 East unnamed guyot, H1940) and the occurrence of basalt morphologies overlying limestones (e.g., Wetmore Seamount, H1933) suggests that some guyots in the region may have undergone multiple, discrete volcanic phases. The origin and history of both the enigmatic ridge and the anomalous guyots require subsequent geochemical and geochronological analyses for interpretation. The long dive transects, coupled with relatively dense sampling (6–10 rocks per dive), will allow for novel insights into how these ancient volcanoes were constructed, for example, via a continuous event or multiple discrete pulses of volcanism.

Biology was notably sparse during the first two dives at unnamed seamounts (H1926, H1927), possibly owing to relatively sluggish current flow in the area. Sponges that dominated the benthic fauna across these seamount landscapes included glass sponges (*Caulophacus* sp. and *Poliopogon* sp.) and those in the family Farreidae. Corals, which more commonly exhibited high-density patches compared to sponges, were represented by golden, bamboo, and black corals (Figure 4). Small nodule patches observed across these sites were found to be populated by sponges in the genus *Semperella*.

In the western and southern portions of the Johnston Unit of the PRIMNM, exploration of a deep unnamed ridge summit (H1931) identified the presence of bamboo coral (Keratoisididae) and sponge (*Poliopogon* sp.) dominated communities. Higher density and more diverse coral and sponge communities were observed at H1932 and H1933 on guyots with prominent northeastward trending ridges. Patchy but high-density sea pen communities (*Balticina* sp.) were found on Johnston Atoll (H1935) along heavily sedimented slopes off the deeper western flank between 1,600 m and 1,800 m depth.

At seamount sites explored north of Johnston Atoll, high-density and diverse deep-water coral and sponge communities were observed on two unnamed seamounts (H1936, H1937), with highest densities often associated with vertical rock surfaces or overhangs. Among the most noteworthy species encountered during this expedition was the sea pen *Solumbellula* during dive H1938 at 2,993 m depth (see page 46, Figure 2a). It is both the first observation and the first collection of this abyssal genus in the Pacific Ocean basin.

Fossilized skull remains of beaked whales coated in ferromanganese crusts were encountered across multiple sites (Figure 5), suggesting a previous ecological relationship between seamount biological resources in this region and these transient marine mammals.

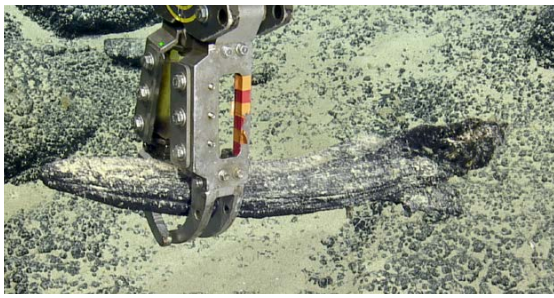


Figure 5. ROV *Hercules* recovering a portion of a fossilized beaked whale skull.

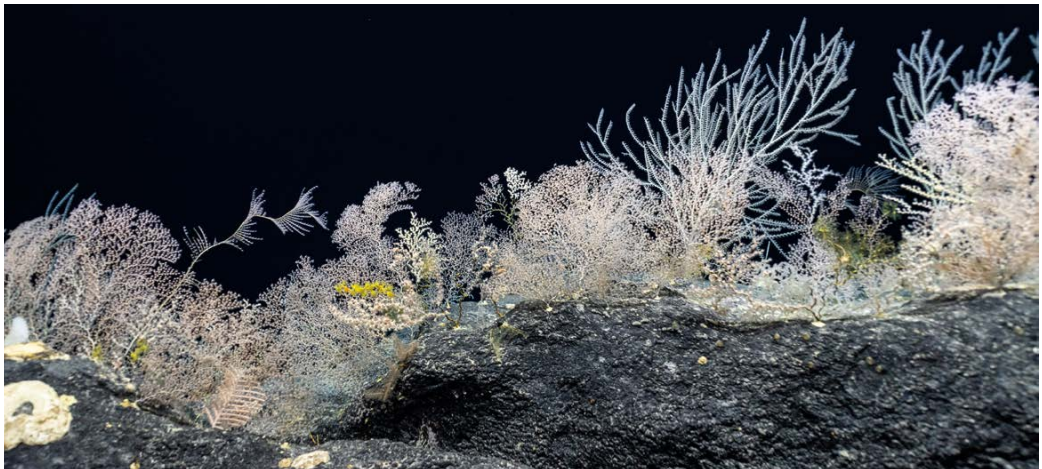


FIGURE 4. An outcrop observed at 1,895 m depth on an unnamed seamount during dive H1930 harbors a high density of golden and bamboo corals, as well as *Poliopogon* sp. glass sponges.